

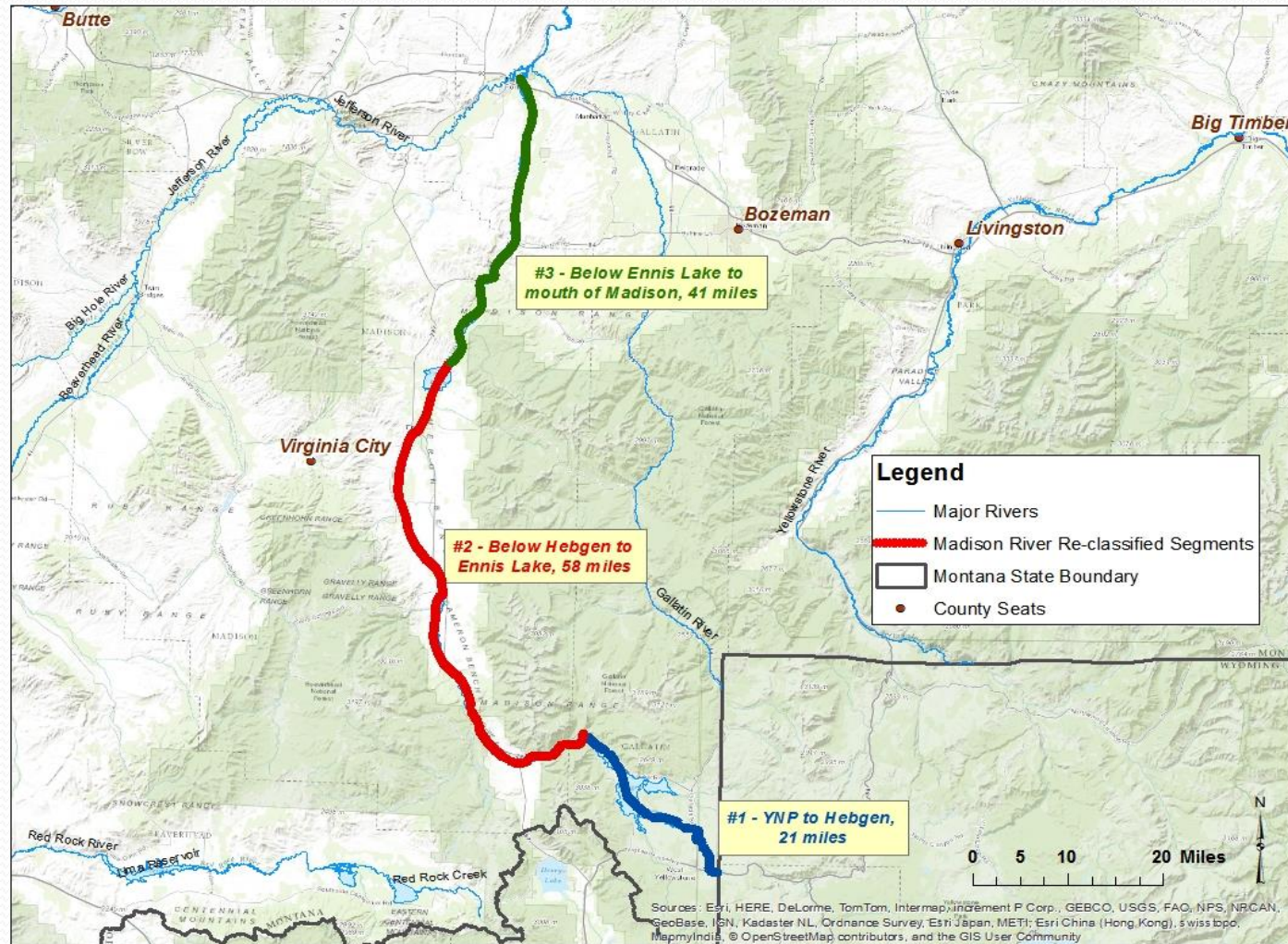
# Nonanthropogenic Standard Selection (NAS)

## Madison River

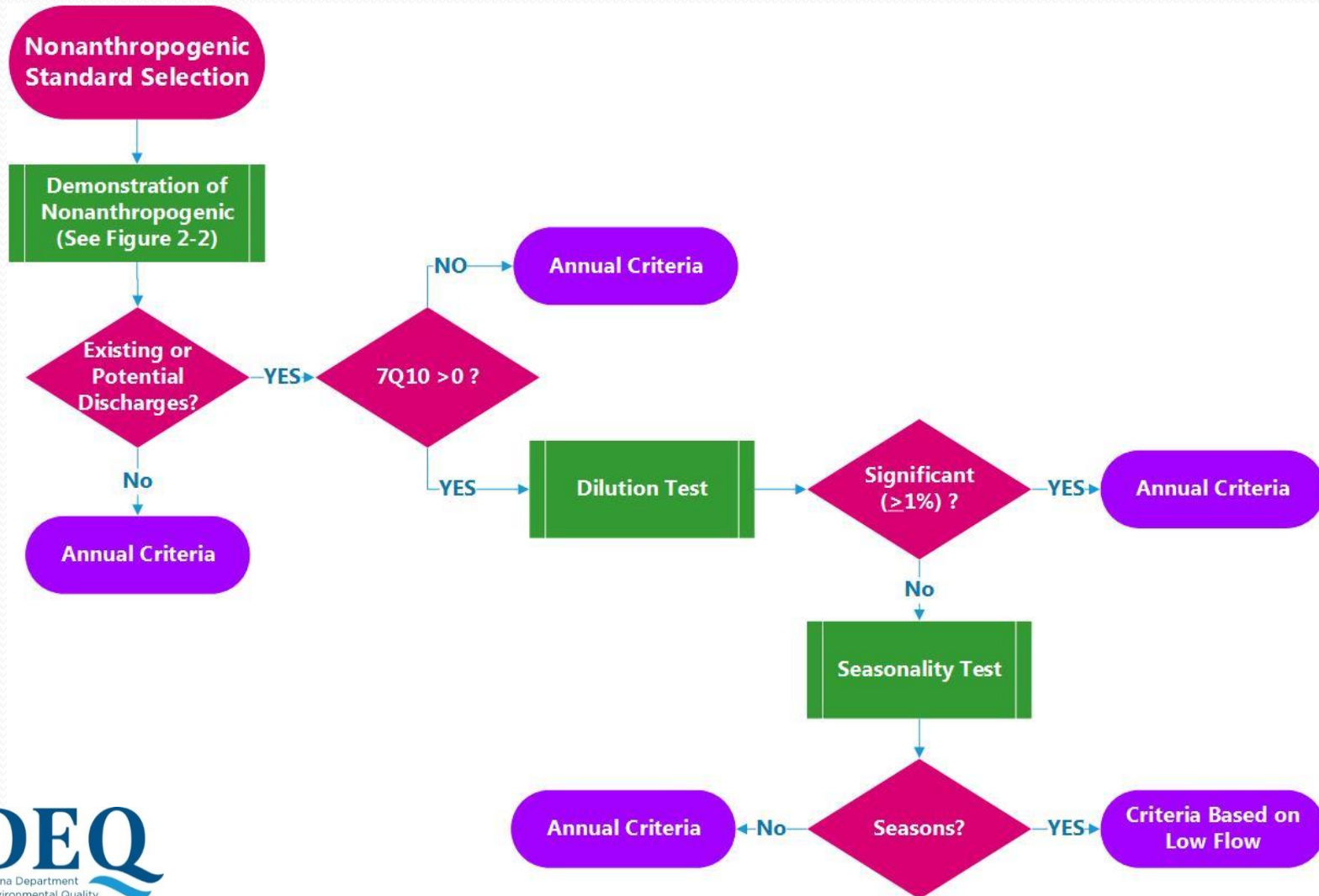
**Melissa Schaar**  
**Water Quality Standards Specialist**  
Water Quality Planning Bureau  
406-444-5226  
[mschaar@mt.gov](mailto:mschaar@mt.gov)



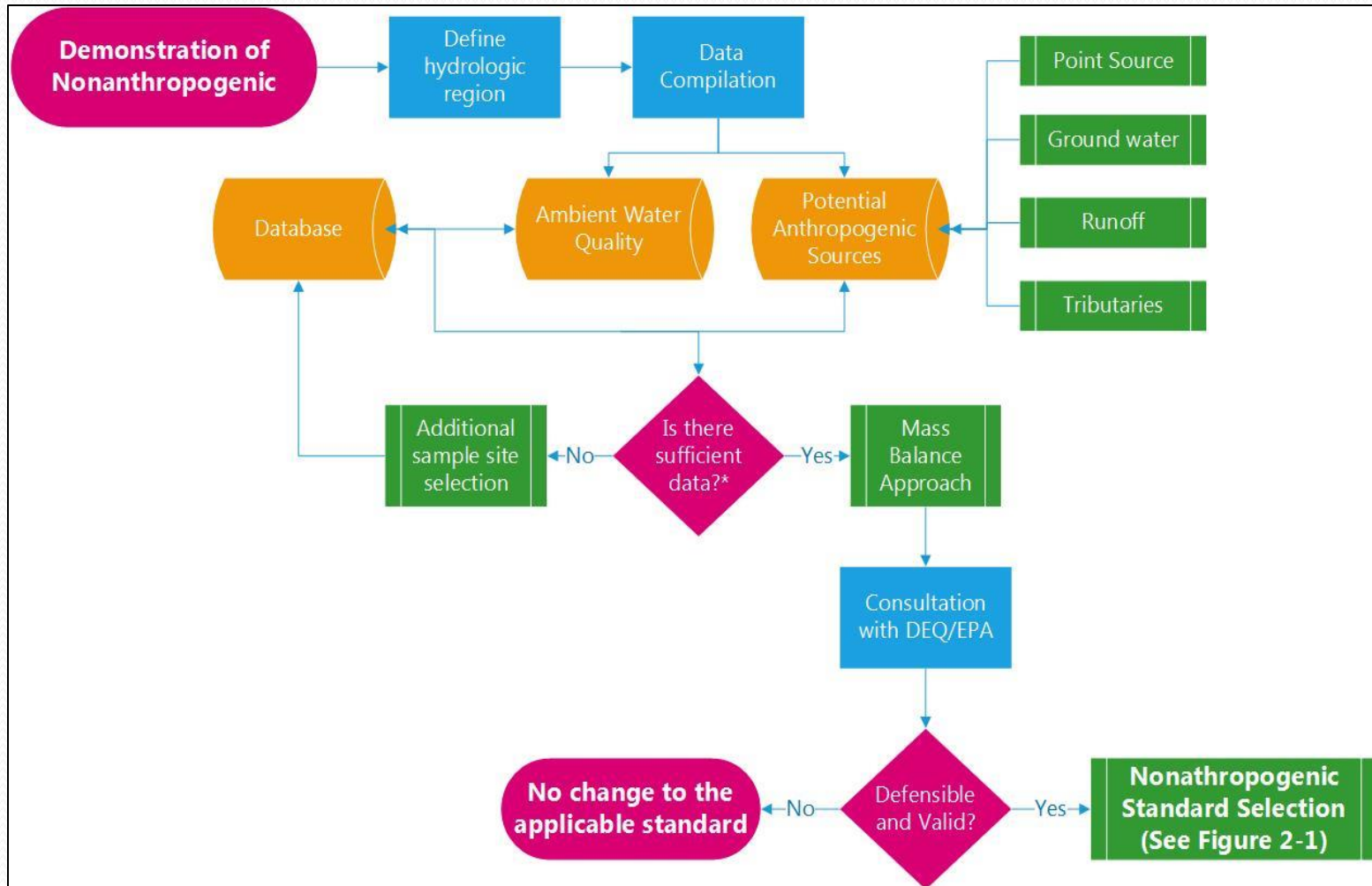
# Madison River Segments for NAS



# NAS Process



# Review: Demonstration of Nonanthropogenic (DON) Process





# Results of DON as Part of NAS Process

1. Nonanthropogenic load is  $\leq 95\%$  of ambient load
  - Standard based on median nonanthropogenic concentration, calculated from modeled median nonanthropogenic load and median flow
2. Nonanthropogenic load is  $> 95\%$  of ambient load
  - Standard may be based on median of ambient concentrations

# Madison River NAS Example

- Three Hydrologic Segments
- Large Datasets ( $n > 100$  per segment)
- Demonstration of Natural Complete
- NAS calculated from:
  - Median Flow Condition
  - Modeled Median Monthly Nonanthropogenic Loads

# Dilution Test for NAS Selection

Case	7Q10 (cfs)	*Discharge Volume % of 7Q10	Standard Selection
1	0	N/A	Annual Standard, All Months
2	> 0	$\geq 1\%$	Annual Standard, All Months
3	> 0	< 1%	Perform Seasonality Determination

\*Current and/or potential discharge volumes with anthropogenic arsenic loads divided by the receiving bodies 7Q10

# Dilution Test – Permitted Discharges, Madison River

MPDES No.	Facility	Receiving Body	Maximum Flow (cfs)	Max Conc. (ug/L)
MTG130008	USFWS-ENNIS NAT FISH HATCHERY*	Madison below Hebgen	30	29
MT0030732	ENNIS WWTP	Madison below Hebgen	0.34	11
MT0000264	THREE FORKS DOMESTIC WWTP	Madison below Ennis Lake	1.02	34

\*No arsenic limits in permit but research suggests potential for anthropogenic arsenic contribution to Madison River



# Dilution Test - Results

Station	USGS Gage Number	7Q10 (cfs)*	Max Permitted Flow (cfs)	Dilution Test (Max Flow/7Q10)	Conclusions
Madison West Yellowstone to Below Hebgen	6037500	304	0	0.0%	Annual Criteria, all months
Madison below Hebgen to Below Ennis Lake	6038500	400	30.3	7.6%	Annual Criteria, all months
Madison below Ennis Lake to Mouth	6041000	731	1.02	0.1%	Use Seasonal Determination

\*7Q10 was obtained from USGS stream stats (USGS, 2015). The stream stat for the USGS gage below Hebgen Lake is very low when compared to other Madison River stations. This error in the calculation resulted from dam management prior to 1984. The 7Q10 for the Madison at Kirby Ranch (6038800) was used in place of the Madison below Hebgen Lake.

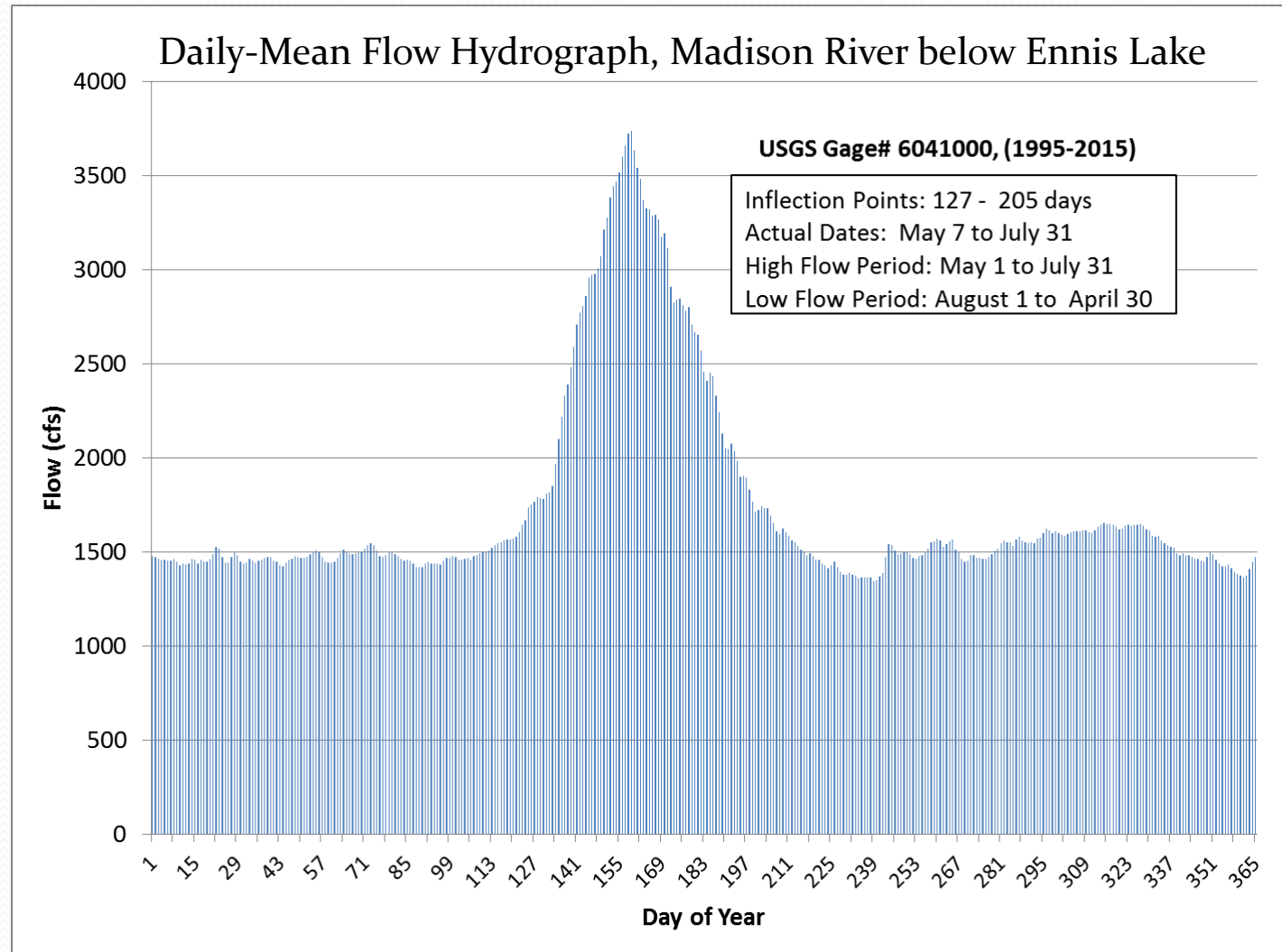
# Seasonal Determination

- Flow Duration Hydrograph
  - Minimum of 5 years of daily flow data
  - Recorded flows for each day of year for period of record averaged and plotted
  - Points of Greatest Inflection – High and Low flow periods
- Mann Whitney Test

Test arsenic concentrations from high and low flow periods for significant differences

  - Significant – one annual standard from low flow months
  - Not Significant - one annual standard from all months

# Seasonal Determination-Hydrograph



## Madison River below Ennis Lake: Model Derived Median Monthly Nonanthropogenic Arsenic Loads, Flow Rates, and Concentrations

Month*	Median Nonanthropogenic Arsenic Load (kg/month)	Median Flow Rate (cfs)	Median Nonanthropogenic Arsenic Concentration (ug/L)
October	7,030	1,390	68
November	7,487	1,460	69
December	8,558	1,390	83
January	9,439	1,460	87
February	8,955	1,465	82
March	10,335	1,450	96
April	9,211	1,370	90
May	11,173	1,880	80
June	12,452	2,660	63
July	8,163	1,630	67
August	6,653	1,330	67
September	6,272	1,300	65

*\*High Flow Period in Blue and the Low Flow Period in Red, derived from Histogram*

# Seasonal Determination Results

## Results for: Worksheet 2

### Mann-Whitney Test and CI: C2, C4

N Median

C2 3 67.29

C4 9 82.14

Point estimate for  $\eta_1 - \eta_2$  is -6.01

95.8 Percent CI for  $\eta_1 - \eta_2$  is (-27.44, 11.91)

W = 12.0

Test of  $\eta_1 = \eta_2$  vs  $\eta_1 \neq \eta_2$  is significant at 0.1956

alpha = .05

p-value = .1956

$p > \alpha$ ; therefore, the data does not support the hypothesis that there is a difference between the population medians.

Not Significant

- Mann-Whitney Test using Minitab
- Concentrations are not significantly different between high and low flow period
- NAS selected is an annual standard of all the monthly modeled nonanthropogenic concentrations

# Summary: NAS for the Madison River

Madison River Hydrologic Segments	Type of Standard	NAS (ug/L)
West Yellowstone to below Hebgen Lake	*Annual, all months	240
Below Hebgen Lake to below Ennis Lake	*Annual, all months	132
Below Ennis Lake to the mouth of the Madison River	*Annual, all months	75

\*Based on median monthly modeled nonanthropogenic arsenic concentrations



# Yellowstone River NAS Example

- Small dataset ( $n=15$ )
- Nonanthropogenic loads have not yet been calculated
- Ambient concentrations used to calculate NAS, example only

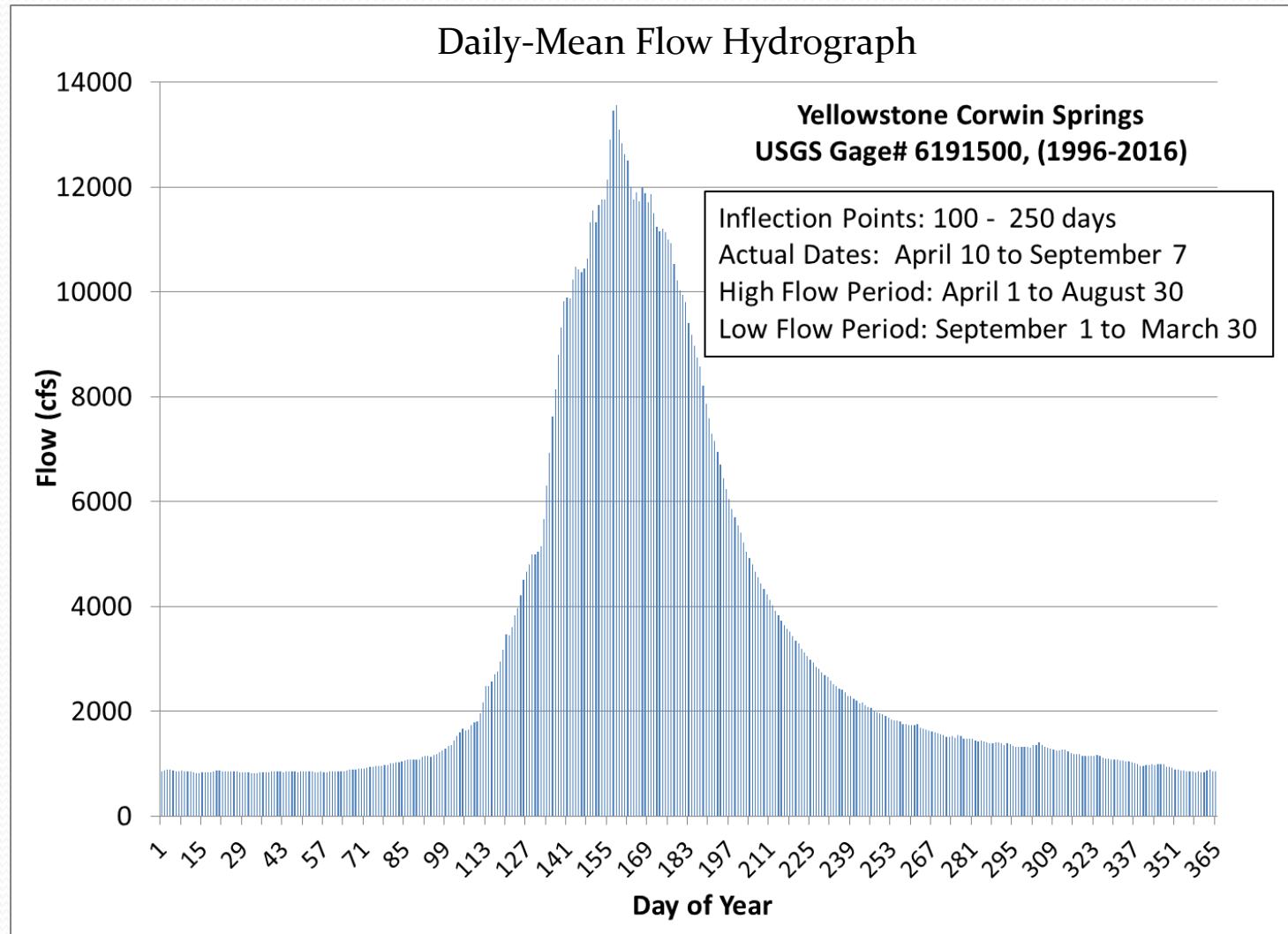
# Dilution Test – Permitted Discharges, Yellowstone River at Corwin Spring

<b>MPDES No.</b>	<b>Facility</b>	<b>Receiving Body</b>	<b>Maximum Flow (cfs)</b>	<b>Max Conc.(ug/L)</b>
MT0022705	GARDINER WWTP	Yellowstone River before Corwin Springs	0.69	159
MT0030252	TVX MINERAL HILL INC - TVX MINERAL HILL MINE	Bear Creek, Tributary to Yellowstone River above Corwin Springs	0.48	48

# Dilution Test - Results

Station	USGS Gage Number	7Q10 (cfs)*	Max Permitted Flow (cfs)	Dilution Test (Max Flow/7Q10)	Conclusions
Yellowstone River at Corwin Springs	6191500	501	1.17	0.2%	Use Seasonal Determination

# Seasonal Determination - Hydrograph



## Yellowstone River at Corwin Springs: Ambient Arsenic Concentrations and Flow Rates

Date	Tot AS (ug/L)	Flow
1/17/2017	36	959
3/12/2016	41	869
5/2/2015	9	6970
5/21/2016	8	8920
6/3/2015	7	10100
7/8/2015	18	3820
7/28/2016	24	2400
8/9/2015	19	2820
9/12/2015	33	1220
9/11/2016	33	1040
10/11/2015	33	1100
10/26/2016	25	1650
11/7/2015	31	1020
11/16/2016	24	1680
12/13/2016	31	1050

*\*High Flow Period in Blue and the Low Flow Period in Red, derived from Histogram*

# Seasonal Determination Results

## Mann-Whitney Test and CI: C1, C2

	N	Median
C1	6	13.50
C2	9	33.00

Point estimate for  $\eta_1 - \eta_2$  is -17.00

96.1 Percent CI for  $\eta_1 - \eta_2$  is (-24.99, -9.00)

W = 21.5

Test of  $\eta_1 = \eta_2$  vs  $\eta_1 \neq \eta_2$  is significant at 0.0022

The test is significant at 0.0021 (adjusted for ties)

alpha = .05

p-value = .0021

p < alpha; therefore, the data does support the hypothesis that there is a difference between the population medians.

Significant  
Seasonality

- Mann-Whitney Test using Minitab
- Concentrations are significantly different between high and low flow period
- NAS selected is an annual standard based on low flow month concentrations



# Summary: NAS for the Yellowstone River at Corwin Spring

Hydrologic Segments	Type of Standard	NAS (ug/L)
Yellowstone River at Corwin Springs	Annual, low flow months	33

\*\*If the annual standard was based on all data (high and low flow months) the standard would be 25 ug/L

# Questions?